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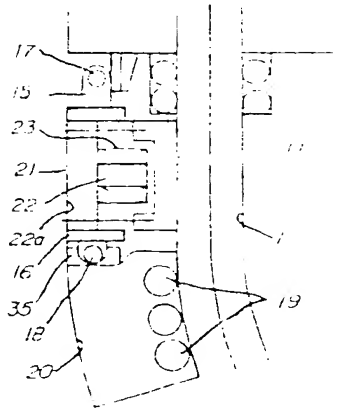
(54) ELECTROMAGNETIC STIRRING APPARATUS FOR CONTINUOUS CASTING MACHINE

(57) An electromagnetic stirring apparatus is provided at any convenient position between a part directly below a mold of a continuous casting machine and a secondary cooling zone so that it is in close proximity to a casting which still has unsolidified molten metal therein, as well as surround it. Fundamentally, an integral structure is formed by a guide plate which is provided with a cooling function and a coil removably mounted on the rear of the guide plate about a core, so that the coil is as close as possible to the casting

FIG_4



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TITLE MODIFIED
see front page

SPECIFICATION

AN ELECTROMAGNETIC STIRRING APPARATUS FOR USE IN A CONTINUOUS CASTER

Technical Field

This invention relates to an electromagnetic stirring apparatus arranged just beneath a mold in a secondary cooling zone of a continuous caster and combined with guide means, and more particularly an electromagnetic stirring apparatus used for stirring unsolidified molten metal, which is contained in a cast strand drawn from the mold, while guiding and cooling the cast strand so that the solidification structure may be improved to enhance the quality of the cast slab or bloom.

Background Technique

Recently, there has been widely used, a technique for stirring molten metal such as molten steel by use of an electromagnetic force in order to improve the quality of the cast slab or bloom, particularly, the solidification structure thereof in the field of the continuous casting of steel or the like. Although the use purpose of such an electromagnetic stirring is different depending upon an installing place, when the electromagnetic stirring is applied, for example, to the mold for the continuous casting, it lies mainly in flowing molten steel to promote floating of bubbles and inclusions and hence

removals of bubble defects such as pinholes and blow holes and non-metallic inclusions. Further, the electromagnetic stirrer arranged at the secondary cooling zone beneath the mold is aimed mainly at the increase of equiaxed crystal zone ratio.

Since the idea per se that the electromagnetic stirrer is attached to the continuous caster is a technique quite recently adopted, a concrete structure of the stirrer has not yet been generalized. Therefore, a concrete example of the stirrer arranged together with the guide means beneath the mold aiming at the invention is not clearly found in the prior art, but the arrangements of the stirrer just beneath the mold as shown in Figs. 1 and 2 are considered as an extension of the prior art.

Such a guide means arranged just beneath the mold is necessary for preventing the cast strand having a thin solidification shell just beneath the outlet of the mold from being broken or deformed due to the unsolidified molten steel remaining in the interior thereof, and also preventing the friction against the lower end portion of the inner wall of the mold. In general, foot rollers (Fig. 1) are arranged in rows or guide plates (Fig. 2) are adopted.

Fig. 1 is an embodiment of the guide means designed as foot rollers 3 for supporting the cast strand just beneath the mold 2, behind (on the outer side) which is arranged a ring-shaped coil 4 of

a rotating magnetic field system. In this embodiment, the coil 4 is so remote from the cast strand that the magnetic force is largely reduced to drop the stirring force, an induced current is produced in the foot rolls 3 to cause troubles such as electrolytic corrosion and the like, and further it is structurally difficult to conduct spray cooling on a steel strand 1.

Fig. 2 is an embodiment of the guide means in which guide plates 6 for the protection of the coil, which also serve to guide the cast strand, are arranged in front of the coil 4 of the rotating magnetic field system. Although this embodiment has the merit that it is possible to put the coil 4 close to the cast strand 1, the guide plates 6 can not cool the cast strand 1, so that there is a risk of causing abnormal bulging of the cast strand 1 due to the insufficient cooling. Moreover, if the guide plate 6 is made into a water-cooled structure capable of cooling the cast strand, the thickness thereof becomes larger, and the merit of approaching the coil to the cast strand is lost.

It is, therefore, an object of the invention to provide an electromagnetic stirring apparatus with a compact structure which is free from the problems encountered by the conventional electromagnetic stirrer arranged beneath the mold, and gives effectively a stirring force required for the improvement of the quality togehter with a guiding function inherent to the water-cooled guide plate.

Further, it is another object of the invention to provide an electromagnetic stirring apparatus with a compact structure which is free from the problems encountered by the conventional electromagnetic stirrer arranged beneath the mold, performs a satisfactory cooling while developing an inherent guiding function, and effectively gives a stirring force required for the improvement of the quality.

Disclosure of the Invention

In order to realize the above objects, the invention proposes an electromagnetic stirring apparatus for use in a continuous caster, comprising a plurality of guide plates each arranged so as to close about a cast strand containing an unsolidified molten metal therein beneath a mold and provided with a flow path for a cooling liquid, and a plurality of electromagnetic coils each containing an iron core therein, said iron core being detachably attached at its front face to the respective guide plate; and an electromagnetic stirring apparatus for use in a continuous caster, comprising a plurality of guide plates each arranged so as to close about a cast strand containing solidified molten metal therein beneath a mold and provided with a plurality of spray holes opening to the cast strand, and a plurality of electromagnetic coils each containing an iron core therein, said iron core being detachably attached at its front face to the respective guide plates.

The invention of the above mentioned

construction provides a compact apparatus with a so-called combined structure of electromagnetic stirrer and guide means which can perform the cooling enough to prevent break-out and bulging and the stirring efficient to obtain a solidification structure with a high equiaxed crystal zone ratio.

Brief Description of the Drawings

Figs. 1 and 2 are schematic views illustrating the known apparatus, respectively;

Fig. 3 is a plan view of an embodiment of the apparatus according to the invention;

Fig. 4 is a schematic view illustrating another embodiment of the apparatus according to the invention corresponding to claim 1;

Fig. 5 is an enlarged sectional view of the embodiment shown in Fig. 4;

Fig. 6 is a partially sectional view as viewed from an arrow direction of Fig. 3;

Fig. 7 is a front view of a guide plate as viewed from a B-B arrow direction of Fig. 6;

Fig. 8 is a partially sectional view of a further embodiment of the apparatus according to the invention; and

Fig. 9 is a plan view of a specific example of the invention for casting a round billet.

Best Mode for Carrying Out the Invention

The invention will be described in detail with reference to the accompanying drawing. The invention

is characterized by having a compact structure obtained by combing guide plates as the conventional guide means with an electromagnetic coil.

A guide plate shown by numeral 11 is to cool a cast strand 1 and is provided at its inside with a flow path 12 for a cooling liquid as shown in Figs. 4-5. In general, a cooling water is introduced from a lower supply tube 14 and drawn out from an upper discharge tube 13, whereby the guide plate 11 is cooled per se and at the same time the cast strand 1 is cooled to promote the solidification thereof. The guide plate 11 is attached to an iron core 22, while the upper side of the core 22 is engaged with the lower end of the mold to be movable in up and down direction through a blacket 15 and a pin 17 and the lower side of the core is placed on a saddle 35 disposed on an upper end of a segment 20 for support rolls 19 through a blacket 16 and a pin 18. With this construction, the front face of the guide plate is brought near the cast strand containing an unsolidified molten steel therein and a set of plural guide plates are supported in suspension so as to surround the cast strand 1.

An electromagnetic coil 21 is arranged behind each of the guide plates 11. That is, the coil 21 is composed of an iron core 22 and a winding 23. As shown in Figs. 3 and 9, when the outer end portions of the cores 22 are connected to a common member 22a of a ring shape, the support structure becomes more simplified,

but they may be independently supported in suspension.

Each coil 21 is integrally fitted to the back face of the respective guide plate 11 by screwing bolts 24a and 24b from the common member 22a to the guide plate 11. Between the front end face of the core 22 and the back face of the guide plate is interposed a shim 26 through the bolts 25. This shim 26 is utilized to adjust the gap between the guide plate 11 and the cast strand 1, for example, when the guide plage 11 is worn. In the illustrated embodiment, there is shown the shim 26 fitted to the front face of the core 22, but to the contrary it may be fitted to the guide plate 11.

In Figs. 6-8, is shown another embodiment of the invention. In this embodiment, a guide plates 11' is provided with a plurality of spray holes 27 opening to the cast strand 1. Each of the spray holes 27 is communicated with a supply header 28 formed in the middle portion of the guide plate 11', so that a cooling liquid introduced from an inlet tube 29 is distributed into the spray holes 27 through the header 28 and spouted onto the surface of the cast strand 1 to cool the solidified shell of the cast strand.

When the header 28 is positioned in the middle portion of the guide plate 11' as shown in Fig. 6, a flow path 30 for the cooling liquid is arranged so as to pass through the central portion of the core 22, through which the inlet tube 29 is connected to the

supply header 28 for supplying the cooling liquid into the spray holes 27. Moreover, when a recess 31 is formed around the open end of the spray hole 27 as shown in Fig. 7, it is convenient to obtain a uniform film-like flow of the cooling liquid.

In Fig. 8 is shown an embodiment of the electromagnetic stirring device in which the thickness of the guide plate 11' is made thinner to suppress the attenuation of the electromagnetic force with a large magnetic field penetration depth. For this purpose, two headers 28 are arranged in the vicinities of the upper and lower end portions of the guide plate and independently connected to the inlet tubes 29 and 29', respectively.

With the above construction, when the shim 26 interposed between the front face of the core 22 and the guide plate 11' is a thickened liner, it serves for core alignment and for adjustment when the size of the cast strand is changed.

In the above embodiments of Figs. 6-8, the constituent features which are omitted for their explanation are the same as in Figs. 4-5, wherein the integral structure of the guide plate 11' and the coil 21 is obtained by tightening of the bolt 24a, and 24b. When the electromagnetic stirring apparatus is arranged just beneath the mold 2, it is supported in suspension at the bottom of the mold by means of the securing bolts 32 and 33 through the flange 34.

In the electromagnetic stirring apparatus according to the invention, a rotating magnetic field is produced by flowing an alternating current through the coil 21, whereby molten steel in the cast strand can be stirred, for instance, in a direction shown by an arrow in Fig. 3.

As mentioned above, the apparatus according to the invention itself has the following merits.

(1) Since the guide means for the cast strand is integrally incorporated into the electromagnetic coil body, the apparatus is made compact. For this reason, since the coil can further approach to the cast strand as compared with the conventional apparatus, it is possible to obtain more enhanced stirring effect and the apparatus is miniaturized with the coil being made smaller.

(2) Since the guide plate for cast strand is equipped with a closed type or open spray type water cooling mechanism for cast strand, it can be arranged and used at an arbitrary location from just beneath the mold to the secondary cooling zone where the cast strand is required to be cooled.

(3) Since the guide means itself is constructed to fully offset the wear-out thereof by the adoption of the shim or the like, the apparatus according to the invention is satisfactorily applicable to the actual operation.

(4) Since the apparatus is compact, it is easy to

install it into the existing continuous caster.

Industrial Applicability

The aforementioned electromagnetic stirring apparatus is suitably used in a continuous caster for metals such as steel, aluminum and the like.

What is claimed is:

1. An electromagnetic stirring apparatus for use in a continuous caster, comprising a plurality of guide plates each arranged so as to close about a cast strand containing an unsolidified molten metal therein beneath a mold and provided with a flow path for a cooling liquid, and a plurality of electromagnetic coils each containing an iron core therein, said core being detachably attached at its front face to the respective guide plate.

2. The apparatus according to claim 1, wherein a shim is detachably interposed between the front end face of the core and the back face of the guide plate by means of bolt.

3. The apparatus according to claim 1, wherein the outer sides of the cores are integrally supported by a common member of ring-like shape.

4. An electromagnetic stirring apparatus for use in a continuous caster, comprising a plurality of plural guide plates each arranged so as to close about a cast strand containing an unsolidified molten metal therein beneath a mold and provided with a plurality of spray holes opening to the cast strand, and a plurality of electromagnetic coils each containing an iron core therein, said iron core being detachably attached at its front face to the respective guide plate.

5. The apparatus according to claim 4, wherein the spray holes are positioned on the extension of branched passages from a supply header formed in the guide plate.

6. The apparatus according to claim 5, wherein the supply header is formed in the central portion of the guide plate.

7. The apparatus according to claim 5, wherein the supply headers are formed in the vicinities of the upper and lower ends of the guide plate.

8. The apparatus according to claim 5, wherein in the case of the supply header being formed in the central portion of the guide plate, a flow passage communicating with the supply header is arranged in the core.

9. The apparatus according to claim 4, wherein a shim is detachably interposed between the front end face of the core and the back face of the corresponding guide plate by means of bolt.

10. The apparatus according to claim 4, wherein the outer sides of the cores are integrally supported by a common element of a ring-like shape.

FIG_1

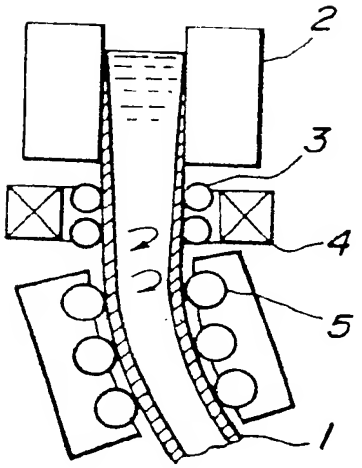


FIG_2

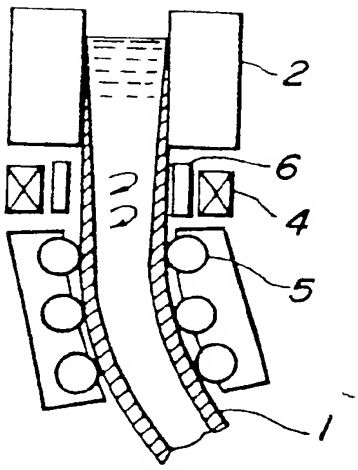


FIG_3

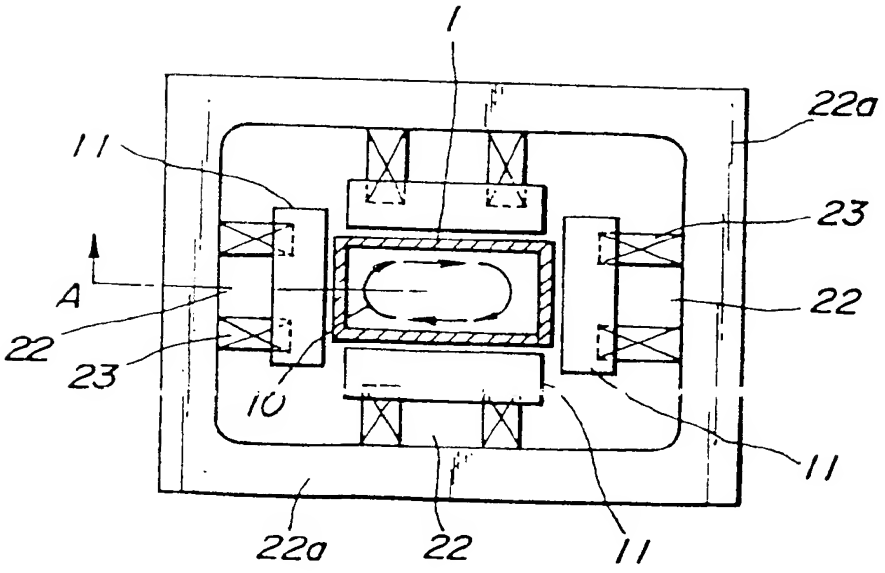


FIG_4

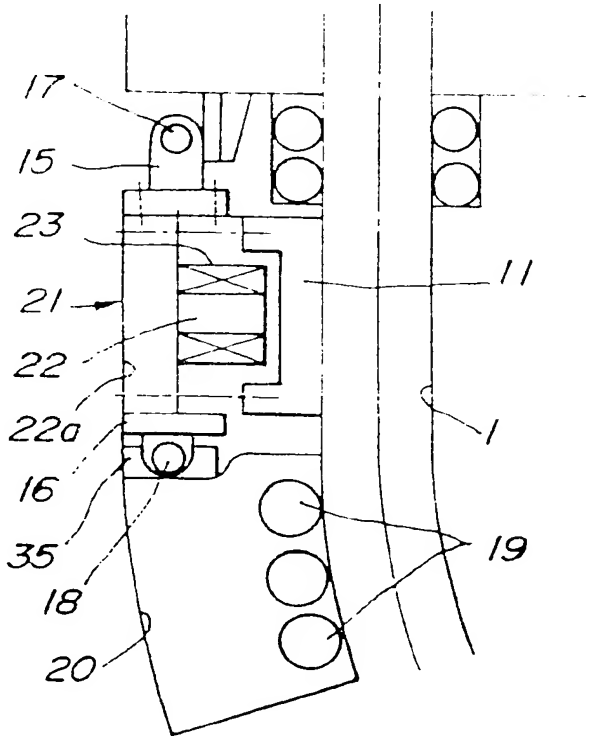

17
15
23
21
22
22a
16
35
18
20
11
1
19

FIG_5

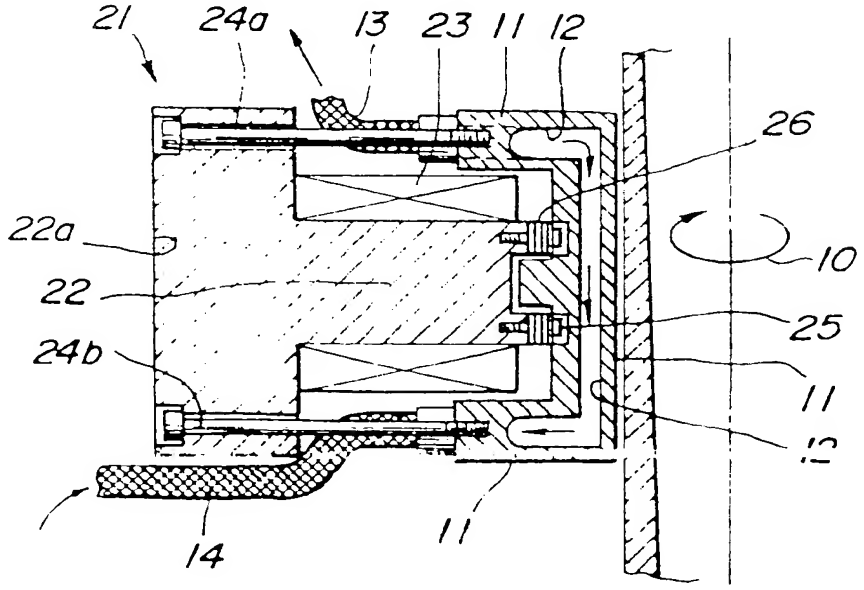
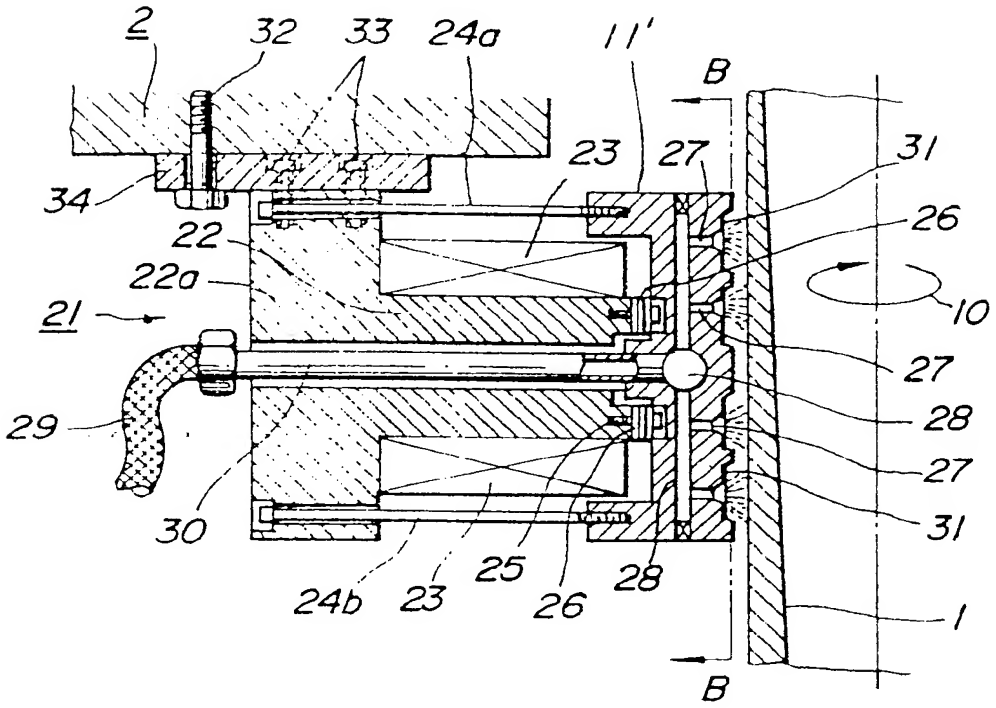

21
24a
13
23
11
12
26
22a
22
24b
10
25
11
12
14
11

FIG_6


2
32
33
24a
11'
B
23
27
31
34
26
22
22a
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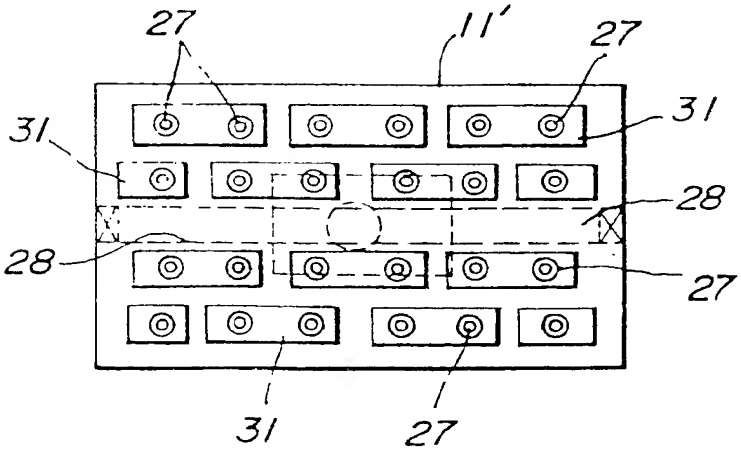
29
27
31
30
25
28
24b
23
26
1
B

FIG_7


27
11'
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31
31
28
28
27
31
27

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FIG_8

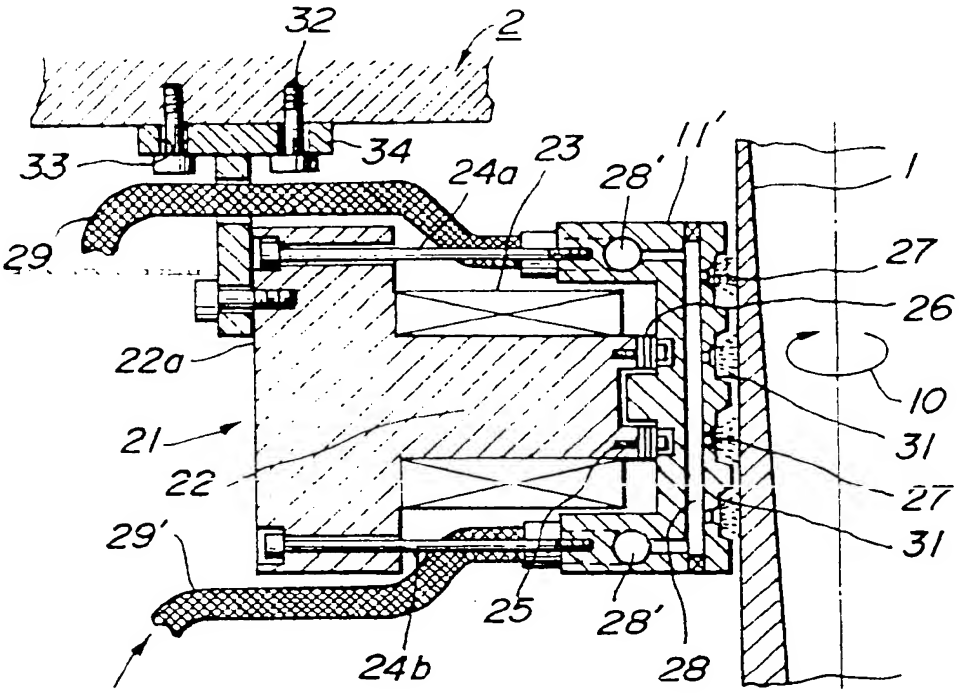
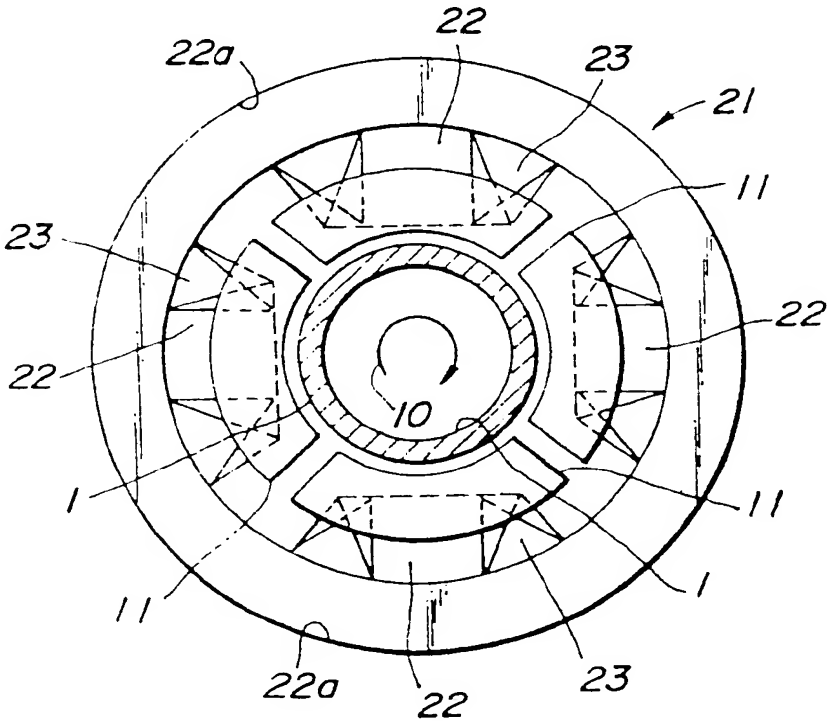


FIG_9



INTERNATIONAL SEARCH REPORT

International Application No. PCT/JP83/00433

0165316

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [2]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[3] B22D 11/10, 11/124

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC	B22D 11/10, B22D 11/12

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

Jitsuyo Shinan Koho	1926 - 1983
Kokai Jitsuyo Shinan Koho	1971 - 1983

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category*	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
E	JP, A, 58-215254 (Kawasaki Steel Corp.) 14 December 1983 (14. 12. 83)	1 - 10
A	JP, A, 57-94458 (Mitsubishi Heavy Industries, Ltd.) 11 June 1982 (11. 06. 82)	1

* Special categories of cited documents: [15]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [3]	Date of Mailing of this International Search Report [3]
March 5, 1984 (05. 03. 84)	March 12, 1984 (12. 03. 84)
International Searching Authority [1]	Signature of Authorized Officer [20]
Japanese Patent Office	